**Reading Report**

The report summarizes and critiques the paper presented on “**Flying Multiple UAV’s Using ROS**” authored by Wolfgang H ̈onig and Nora Ayanian. This paper is basically a tutorial to teach using ROS for flying a small quadcopter (in this case Bitcraze Crazyflie 2.0) both individually and as a group. The main motivation for the paper is to provide step-by-step instructions for operating a Crazyflie. The author points out that even though there is a huge amount of research and software packages available on usage and operation of UAVs, all this content is extremely complicated. Also, there is a lack of documentation on multi-UAV systems. Even the packages that support multiple UAVs the documentation focuses on the single UAV case.

The paper grows in steps, first the author explains the crazyflie\_ros stack, its design and how it can be used. This allows readers to understand the package in depth and also to make changes to the stack for custom applications on other robot platforms as well. Then the author moves gradually from explaining hovering and waypoints for individual quadcopters to multi-UAV systems. The quadcopter used in the paper is the Bitcraze Crazyflie 2.0 which is an open-source open – hardware nano quadcopter with size of 92mm (diagonal rotor-to-rotor) and weight of 29 gm. Its small size makes it ideal for indoor swarming applications.

There are multiple packages available such as the AscTec pelican, Parrot AR. Drone etc. that can be operated using ROS. Although these packages are efficient in handling individual robot they are not capable of working with multi-UAV system. When it comes to handling multiple UAVs, there are a lot of issues that needs to be addressed such as the physical space required to operate these UAVs, the interference of sensors and network communication systems, and the safety requirements for the system. In order to operate Crazyflie, an external position tracking system, such as motion capture system is required because the Crazyflie is not able to localize itself with just the onboard sensing. Everything discussed in the paper has been tested on Ubuntu 14.04 using ROS Indigo. The crazyflie\_ros stack and discussed software also work with ROS Jade (Ubuntu 14.04) and ROS Kinetic (Ubuntu 16.04).

Next, the author describes the target platform. Some of the important feature described by the author are as follows: The Crazyflies operates mainly on two microcontrollers: STM32 and nRF51. The STM32 or the main microcontroller is responsible for state-estimation, control, and handling of extensions. The nRF52 is responsible for radio and power management. Both microcontrollers communicate over the syslink, which is a protocol using UART as a physical interface. The Crazyflie also have an extension port the permits the addition of additional hardware such a inductive charger, LED headlights, and buzzer. A crazyflie can communicate with a PC or a phone through BlueTooth. Additionally, a custom USB dongle called Crazyradio is used that allows lower latency communication.

After the architecture of Crazyflie comes the setup of the system. The author described each setup step from Crazyflie software, PC permissions, Bitcraze Crazyflie PC client, Firmware, and Crazyflie ROS stack great detail with screenshots and terminal commands. The author also mentioned various permission senarious and how user should handle them. After the setup author started off with teleoperation on a single quadcopter. Here the author used the Microsoft Xbox360 joystick to control the quadcopter. After single quadcopter author moves on to describing teleoperation for multiple quadcopter.

Once the user gets a bit used-to to teleoperation the author explains some of the key concepts like communication parameters, ROS usage for multiple crazyflie, hovering, position estimation, and waypoints. The author also shares few troubleshooting tips. The position racking system used here is the VICON so in the later section of the paper the author describes VICON setup and how different nodes can communicate using rqt\_graph.

The paper is very well written with each aspect of working with a UAV system described in detail. The author organized each step very well including all the necessary details especially the troubleshooting section which is generally missing in a lot of documentation. The author did complete justice to the purpose of creating a tutorial for using multiple UAV system.